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Coronary Artery Bypass Surgery Morbidity

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A retrospective analysis was undertaken of 365 consecutive patients, 75 women and 290 men with a mean age of 59.9 ± 9.7 years, who had coronary artery bypass surgery during 1981. Complications classified as major were: mediastinal hemorrhage, pericardial tamponade, wound dehiscence, sternal osteomyelitis, myocardial infarction, bacterial endocarditis, dissecting aneurysm and diabetes insipidus. Complications classified as minor were: atrial fibrillation, postpericardiotomy syndrome, cellulitis, thrombophlebitis and phrenic nerve palsy.

There were 48 patients (13%) with 52 major complications. Age more than 60 years, cardiopulmonary bypass time longer than 150 minutes, aortic cross-clamp time longer than 100 minutes, number of grafts greater than five and presence of diabetes mellitus were significantly associated with major complications. Complications tended to occur more frequently in women, obese patients and those with emergency operation or ejection fraction less than 30%, but the associations were not statistically significant. Physicians referring patients for coronary artery surgery should be cognizant of the incidence of morbidity along with the other risks and benefits when considering coronary artery bypass surgery.

Myocardial revascularization, initially by a patch graft reconstruction, later by coronary artery bypass grafting, was popularized by Effler (1) and Favaloro (2) and their coworkers. For the past 20 years, mortality relative to myocardial revascularization has been reduced as a result of greater technical experience, better myocardial protection and improved patient management (3). However, little attention has been given to morbidity, which may affect the quality of life and the length of hospital stay.

This study analyzes a community hospital experience with direct myocardial revascularization in 1981. Primary attention is paid to analysis of morbidity because such information might influence patient management if the indications for surgery are marginal and a high risk of complications might be expected. We designed this study to determine if clinical findings might help identify patients at higher risk for complications and to emphasize the importance of this little discussed aspect of coronary bypass surgery.

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Methods

Study group (Fig. 1). A retrospective analysis was undertaken of 365 patients, 75 women and 290 men ranging in age from 31 to 81 years (59.9 ± 9.7 mean ± standard deviation), who had isolated coronary artery bypass grafting surgery during 1981. Complications were analyzed in patients undergoing isolated coronary artery bypass grafting with individual saphenous vein grafts and sequential vein grafts. Anesthetic management and intraoperative technique varied very little among the cardiac surgeons.

Definitions. The following definitions were used: *Short-term morbidity* was defined as complications whose onset occurred within 30 days after operation.

Long-term complications were those occurring more than 30 days after operation.

Hospital mortality included death within 30 days after operation.

Perioperative myocardial infarction was diagnosed on the basis of new Q waves in the electrocardiogram and elevated serum cardiac enzymes. When enzyme determinations were discordant with new Q waves, the attending cardiologist made the decision about the presence of infarction.

Minor complications were those considered not life-threatening. Major complications were those considered potentially life-threatening.

Poor left ventricular function was defined as an ejection

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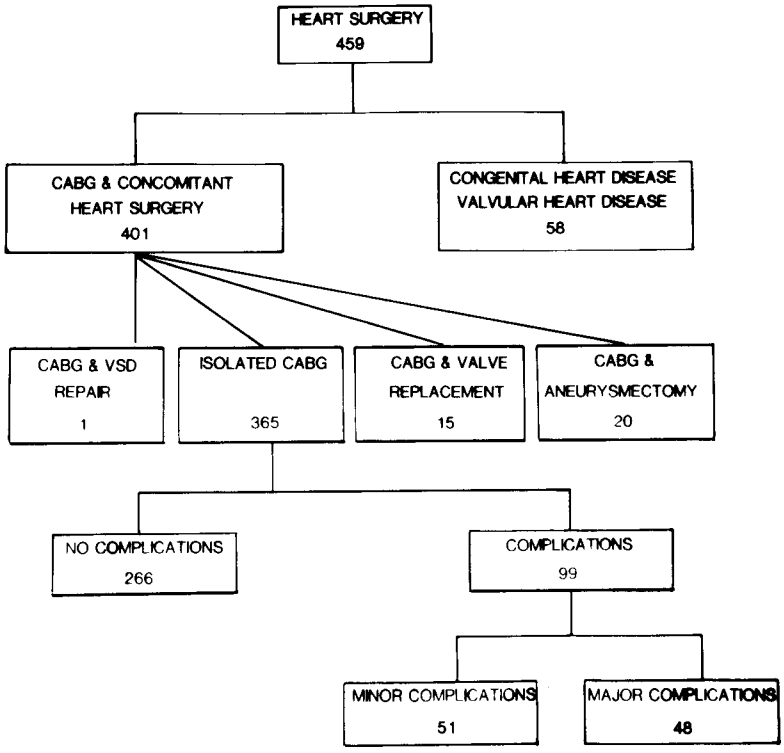


Figure 1. Study group. CABG = coronary artery bypass grafting; VSD = ventricular septal defect.

fraction (measured in single plane exposure by the area-length method [4]) below 30%.

Statistical analysis. Two stepwise discriminant analyses were performed; the variables entered into the discriminant analysis included age, weight, number of grafts, cardiopulmonary bypass time and aortic cross-clamp time. Statistical analysis of discrete variables was performed using the chi-square test. Continuous variables were analyzed by using the unmatched Student's *t* test.

Results

Complications (Table 1)

Ninety-nine (27%) of 365 patients undergoing coronary artery bypass surgery had complications. Fifty-four minor complications occurred in 51 patients (14%), and 52 major complications in 48 patients (13%). Long-term complications were seen in 5 patients (1.4%) and short-term complications in 94 patients (25.8%).

Minor complications. Atrial fibrillation occurred in 25 (49%) of the 51 patients with minor complications. Conversion to sinus rhythm by quinidine and digoxin therapy, cardioversion, or both, occurred in 21 patients, the remaining four had persistent postoperative atrial fibrillation. Postpericardiotomy syndrome occurred in 18 patients (5%). They were treated with a short course of prednisone. Thrombophlebitis, in the leg used to harvest a saphenous vein for coronary artery bypass grafting, occurred in six patients. All six were treated with anticoagulant therapy for 3 to 6 months.

Cellulitis developed in the leg of two patients and in one patient in the arm from which segments of the vein had been removed for construction of grafts. One of these patients had recurrent attacks of cellulitis of the leg. Blood cultures from all three patients were negative. Phrenic nerve palsy after cold cardioplegia occurred in one patient who was asymptomatic. An elevated left hemidiaphragm remained unchanged on follow-up chest roentgenogram 15 months postoperatively. There was one patient with ileus who was treated medically and recovered on the sixth postoperative day.

Major complications. In the group with major complications, seven (1.9%) had mediastinal hemorrhage, associated in two with pericardial tamponade. All seven required thoracotomy. Seven patients had postoperative arrhythmias requiring permanent pacemaker implantation. Five patients (1.4%) had stroke that in three was severe with hemiplegia and dysphasia. Intraoperative myocardial infarction occurred in four patients (1.1%).

Occlusion of the graft led to repeat coronary bypass grafting in four patients (1.1%), within 4 weeks in two patients and within 6 months after the first operation in the other two. Wound dehiscence in three patients (0.8%) required reclosure. Three patients developed congestive heart failure postoperatively. Chest tube drainage for tension pneumothorax was carried out in three patients. Sternal osteomyelitis occurred in three patients and a long course of antibiotic therapy was given after reoperation in these cases. Two patients (0.6%) had pulmonary emboli. They received 6 months of anticoagulant therapy. An intraaortic balloon pump

Table 1. Complications of Isolated Coronary Bypass Surgery in 365 Patients

Complications	Short-Term	Long-Term
Minor (total = 54 in 51 patients)		
Atrial fibrillation	25	
Postpericardiotomy syndrome	17	1
Thrombophlebitis, leg	6	
Cellulitis, leg or arm	3	
Phrenic nerve palsy, left	1	
Ileus	1	
Major (total = 52 in 48 patients)		
Arrhythmias requiring permanent pacer	7	
Mediastinal hemorrhage	5	
With cardiac tamponade	2	
Stroke	5	
Postoperative myocardial infarction	4	
Repeat coronary bypass grafting	2	2
Wound dehiscence	3	
Congestive heart failure	3	
Pneumothorax requiring chest tube	3	
Sternal osteomyelitis	2	1
Pulmonary emboli	2	
Low cardiac output requiring intraaortic balloon pumping	2	
Transient diabetes insipidus	2	
Sternal fracture	1	
Renal failure requiring dialysis	1	
Septic shock	1	
Infective endocarditis	1	
Aortic dissecting aneurysm	1	
Ventricular fibrillation	1	
Leg ulcer requiring amputation		1

was used for postoperative low cardiac output in two patients (0.6%). Two patients (0.6%) developed transient central diabetes insipidus immediately after bypass surgery. Arginine vasopressin therapy was required for both patients for 5 days.

There was only one instance of each of the following complications (0.3%): sternal fracture requiring repair, renal failure on short-term hemodialysis, septic shock, infective endocarditis and ventricular fibrillation responding to cardioversion. One patient had aortic root dissection and rupture. He had a sudden decrease in blood pressure 1 hour postoperatively. The patient underwent surgical correction and was found to have an intimal tear at the site of application of the partial occlusion clamp; he survived. One patient with peripheral arterial disease developed a nonhealing leg ulcer from which a segment of the vein had been removed for aortocoronary grafting. The patient finally required amputation of the leg below the knee.

Conditions Associated With Complications

Patient age 60 years or older, cardiopulmonary bypass time longer than 150 minutes, aortic cross-clamp time longer than 100 minutes, number of grafts more than 5 or presence of diabetes mellitus were associated with a significant increase in rate of complications (Fig. 2). Emergency operation, obesity, female sex and ejection fraction below 30% were associated with a tendency to have complications (Fig. 3), but the trend was not statistically significant.

Patients with major complications stayed in the hospital a mean of 18 days compared with 9 days in those without complications. Hospital cost was $29,000 for patients with major complications and $17,000 for those without such complications.

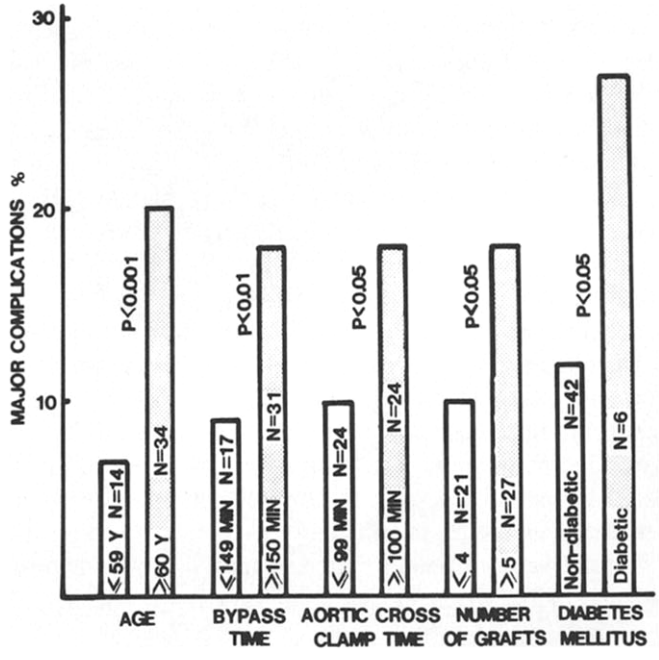
Mortality

Hospital death rate for isolated coronary artery bypass surgery was 3% (11 patients). Causes included myocardial pump failure (six patients), renal failure (one patient), heart failure (two patients) and septicemia (two patients). Hospital mortality was significantly increased in patients older than 60 years of age (9%) and those with ejection fraction less than 30% (50%) and cardiopulmonary bypass time more than 150 minutes (8%).

Discussion

As expected, morbidity differs qualitatively and quantitatively in different patient populations. Memorial Medical Center of Long Beach is a 900 bed community/university-affiliated hospital. The patients are predominantly middle class and come primarily from the immediate vicinity. Community hospitals are the backbone of American medicine

Figure 2. Percent major complications in relation to age, cardiopulmonary bypass time, aortic cross-clamp time, number of grafts and presence of diabetes mellitus. N = number of patients.



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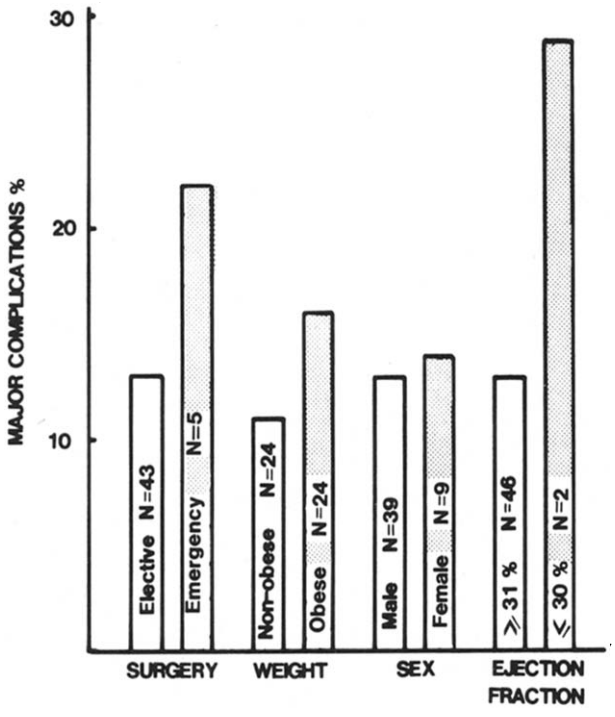

Figure 3. Percent major complications in relation to elective and emergency surgery, patient weight, sex and ejection fraction. These variables were not statistically significant. N = number of patients.

and our experience may be more characteristic than that reported from the major universities and research centers.

Age. Although chronologic and physiologic ages are not necessarily concordant, we found complications related to coronary artery bypass surgery significantly more common in patients older than 60 years of age. A similar conclusion was drawn regarding mortality in the older patients in this study. The risk of coronary artery surgery is generally accepted to be greater in older patients (5–10) than in patients less than 40 years of age (11). However, our mortality rate of 6.2% in this older age group (>60 years) is similar to that found by Gersh et al. (9) (5.2%), but below that reported by Janusz et al. (10) (7.7%).

Time on cardiopulmonary bypass. It has long been believed that duration of cardiopulmonary bypass is directly proportional to morbidity and mortality. Strom (12) showed that the serum creatine kinase MB isoenzyme level shortly after coronary bypass surgery is correlated with the duration of cardiopulmonary bypass, but does not predict a poor outcome. Alfieri et al. (13) found that the probability of low cardiac output after coronary grafting is higher when the period of aortic occlusion is longer (13). However, the cardiopulmonary bypass time may reflect technical difficulties encountered during the cardiac operation, or inability to wean the patient from the bypass pump and may be the first manifestation of impending complications (9). Our experience confirms this concept in that cardiopulmonary bypass times greater than 150 minutes led to a significant increase in morbidity.

Aortic cross-clamp time. The duration of aortic cross-clamping was parallel to that of cardiopulmonary bypass; the latter was 1.5 to 2 times the former. Although prolongation of either period increases morbidity, cardiopulmonary bypass time is more significant than aortic cross-clamp time ($p < 0.01$ versus $p < 0.05$).

Number of grafts. An average of four grafts was inserted per patient in our series. The rate of major complications was significantly increased in patients receiving five or more grafts. We found little correlation between the number of grafts and the duration of cardiopulmonary bypass. This increased complication rate probably relates to overall severity of coronary artery disease including left ventricular dysfunction.

Diabetes mellitus. Patients with diabetes are more susceptible to infection, diffuse arteriosclerosis and delay in wound healing. Thus an increase in complications in diabetic patients might be expected (14). It has been suggested (15) that the duration of diabetes be added to a patient's chronologic age to assess "functional" age; that is, a 50 year old man with a 10 year history of diabetes would be considered to have a cardiovascular system corresponding to that of a 60 year old man without diabetes. Elderly people certainly had increased postoperative complications. Diabetic patients also had a statistically increased complication rate (27%).

Surgical mortality was higher in the diabetic patients studied by Verska and Walker (14) and Johnson et al. (16). In our experience, however, there was only 1 diabetic patient in the group of 11 patients who died perioperatively. The number is too small for statistical analysis.

Emergency coronary surgery. Patients undergoing emergency bypass surgery would be expected to have more complications than those undergoing an elective procedure. In many cases the complication is related to an acute complication occurring before coronary bypass surgery, such as cardiogenic shock (one case), unstable angina (two cases) or complications of coronary angioplasty (two cases). Our complication rate with emergency coronary bypass operations tends to be higher than that in elective cases, but our numbers are too small to be statistically significant.

Obesity. Although surgeons have long blamed obesity for intraabdominal perioperative problems, including anesthesia difficulties (17,18), technical difficulties during operation (19), postoperative respiratory insufficiency (20,21), wound infection and poor wound healing (22,23), wound dehiscence (24) and thromboembolic phenomena (25), we were unable to find any reported data on these potential complications in patients undergoing coronary bypass surgery. Interestingly, our three patients with the complication

of wound dehiscence are obese. This association is probably because of the thicker chest wall, closure being more difficult technically with subsequent increased tension on the wound.

Gender. Women have been reported to have a higher operative mortality rate (26), a higher rate of perioperative myocardial infarction and a markedly lower graft patency rate than men (27–29). The greater frequency of diabetes mellitus in women may be a contributing factor (30). Coronary revascularization is technically more difficult in women because of the smaller thin-walled vessels and the inferior quality of peripheral veins used for grafting. In our experience, however, there was no significant difference in morbidity and mortality between women and men.

Heart failure. Left ventricular dysfunction secondary to ischemia is associated with perioperative mortality in our series, and also in previously reported studies (31–34). Our patients with a low ejection fraction (<30%) also tended to have an increase in complications. However, the difference does not reach statistical significance, which is probably related to the small number of our patients (seven) with poor left ventricular function.

Atrial fibrillation. Atrial fibrillation occurs frequently after coronary bypass surgery. Its incidence varies from 10 to 30% (35–38). Possible etiologic factors are diverse and include regional myocardial ischemia, local metabolic changes, myocardial infarction, postoperative pericarditis and heart failure (39). In most cases, transient atrial fibrillation can be considered a minor complication and has very little overall effect on the patient's outcome.

Buxton and Josephson (40) reported P wave duration as a predictor of postoperative atrial arrhythmias. However, we found the specificity of P wave duration to be quite low (59%).

Infection in legs. Cellulitis in the vein donor leg after coronary bypass surgery affects the integrity of the skin and lymphatic system and makes the wound more susceptible to infection. This previously little discussed iatrogenic disease has been recently reported (41,42). Although microorganisms are infrequently isolated from direct cultures of the skin or from cultures of the blood, it has been postulated (41) that cellulitis is usually a result of streptococcal infection that is mediated by reactions to streptococcal toxin in hypersensitive hosts. This occurred in 0.8% of our patients and caused considerable pain and discomfort but rarely long-term disability.

Postpericardiotomy syndrome. This may occur after intrapericardial surgery and is usually characterized by fever, pleuritic chest pain and pericardial effusion (43,44). Symptoms began between the first and sixth postoperative week. A 6 (45) to 53% (46) incidence rate of postpericardiotomy syndrome has been reported. The 5% incidence rate of postpericardiotomy syndrome in our patients is similar to that reported by Fyfe et al. (47). Although postpericardiotomy syndrome is believed to be a self-limited illness, anti-inflammatory agents with supportive medical or surgical measures are generally used when necessary.

Phrenic nerve palsy. Recently, the use of cold local hyperthermia during cardiac surgery has been associated with paralysis of the phrenic nerve (48,49). Such a cold injury to the phrenic nerve seemed irreversible, as in our patient. A repeat chest roentgenogram did not show any change in the position of the left hemidiaphragm 15 months postoperatively.

Stroke. The incidence of neurologic defects after cardiac surgery is well recognized. The reported incidence rate of cerebral complications after coronary bypass surgery has been similar: 1.3% (50), 1.7% (51) and 1.4% in our series. The precise etiologic mechanism involved is far from clear. While intraoperative factors such as hypotension, microembolism and arrhythmias may be involved, preoperative factors such as hypertension, diabetes, hyperlipidemia, cervical bruits and cigarette smoking may be considered as "risk factors."

Aortic dissection. Aortic root dissection complicating coronary bypass surgery is very rare. Nicholson et al. (52) reported four well documented cases of such complications. All their patients had long-standing severe hypertension and aortic dissection occurred at the aortic site of the saphenous vein anastomosis. It was diagnosed (in two of four patients at autopsy) on the eighth day after coronary bypass grafting or later. In contrast, our patient had no history of hypertension and the intimal tear started at the site of the occlusion clamp. It was associated with rupture and was diagnosed within 1 hour after cessation of cardiopulmonary bypass. Postoperatively the patient has returned home and remains well. Awareness that this potentially fatal complication can occur in the early postoperative period should encourage accurate diagnosis and prompt surgical correction.

Diabetes insipidus. Transient central diabetes insipidus after coronary bypass surgery has not been reported previously. Both of our patients developed hypotonic polyuria, hyperosmolality of plasma and low antidiuretic hormone. They completely recovered within 10 days postoperatively after a short course of arginine vasopressin therapy. Diabetes insipidus after cardiac surgery occurs in some patients who have preexisting selective osmoreceptor dysfunction, when cardiac standstill during cardiopulmonary bypass alters the left atrial nonosmotic receptor function and results in suppression of antidiuretic hormone release (53). It is possible that this disorder has been overlooked in postoperative patients who are healthy as well as those who are critically ill with several medical problems.

Comparison with Cleveland Clinic experience. Zapolanski et al. (51) reviewed the 1981 surgical experience in isolated coronary artery surgery at the Cleveland Clinic.

Table 2. Comparison of Coronary Surgery Morbidity in 1981 Between Cleveland Clinic and Memorial Hospital

	Morbidity (%)	
	Cleveland Clinic	Memorial Hospital
Reoperation for bleeding	2.4	1.9
Stroke	1.7	1.4
Low cardiac output	1.3	0.6
Myocardial infarction	1.4	1.1
Renal failure	0.6	0.3
Respiratory insufficiency	1.6	0
Wound complications	0.5	0.8
Gastrointestinal bleeding	0.2	0

The major complications of the patients undergoing coronary bypass grafting at the Cleveland Clinic were similar to those of our study (Table 2) with the exception that our patients had no respiratory insufficiency. However, Cleveland Clinic morbidity for 1982, recently reported (54), showed different results from those for 1981: namely, reoperation for bleeding (1.8%), stroke (1.8%), myocardial infarction (0.4%), respiratory insufficiency (1.8%), wound complications (1.1%) and gastrointestinal bleeding (0.2%). Important operative risk factors in coronary bypass operations in their experience include: older age, female sex, left main coronary artery lesion, emergency operation and congestive heart failure.

Implications. Physicians should be cognizant of the incidence of morbidity associated with coronary bypass surgery. We believe that a 13% incidence rate of major complications is characteristic of many cardiac centers and propose that physicians should consider the complications along with the other risks and benefits when considering coronary artery bypass surgery.

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